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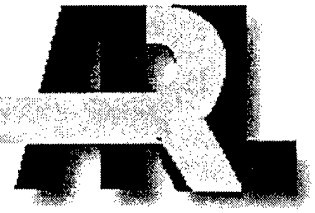

Safety Assessment of Wearing the AN/PVS-14 Monocular Night Vision Device (MNVD) and AN/AVS-6 Aviators' Night Vision Imaging System (ANVIS) During 5-ton and HMMWV Night Driving

Elizabeth S. Redden

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Safety Assessment of Wearing the AN/PVS-14 Monocular Night Vision Device (MNVD) and AN/AVS-6 Aviators' Night Vision Imaging System (ANVIS) During 5-ton and HMMWV Night Driving

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Abstract

The Human Research and Engineering Directorate of the U.S. Army Research Laboratory conducted an assessment to provide the data and analysis of the AN/PVS-14 monocular night vision device (MNVD) and the AN/AVS-6 aviator's night vision imaging system (ANVIS) for the safety certification process. The Communications-Electronics Command Directorate for Safety Risk Management, Fort Monmouth, New Jersey, will use the results of the assessment to determine the suitability of both devices for driving. The four characteristics assessed included (a) the number and nature of training requirements for each system for night driving; (b) the time to complete and the number of errors made while drivers negotiated a hardtop driving course; (c) the time to complete and the number of errors made while drivers negotiated a cross-country driving course; (d) the number and nature of problems related to soldier performance, as well as the number and severity of safety hazards noted.

The 15 soldiers who participated in the assessment drove with the AN/PVS-14, the AN/AVS-6, and the baseline system (AN/PVS-7D) in a predetermined sequence to equalize the environmental and learning effects between systems. Two different terrain driving courses were used: hardtop and cross country. The 15 soldiers were divided into two subgroups: 5-ton truck drivers and high mobility multipurpose wheeled vehicle drivers.

Findings indicated that the soldiers were able to drive with the AN/PVS-14 MNVD and the AN/AVS-6 ANVIS as well as, if not better than, they could with the baseline system (AN/PVS-7D). No problems surfaced that should preclude safety certification of driving with the night vision devices on terrain similar to that used in the study.

Contents

Executive Summary

The goal of this assessment was to provide the data and analysis of the AN/PVS-14 monocular night vision device (MNVD) and the AN/AVS-6 aviator's night vision imaging system for the safety certification process. The Communications-Electronics Command Directorate for Safety Risk Management, Fort Monmouth, New Jersey, will use the results of the assessment to determine the suitability of both devices for driving.

Four characteristics were assessed:

1. The number and nature of training requirements for each system for night driving;

2. The time to complete and the number of errors made while negotiating a hardtop driving course;

3. The time to complete and the number of errors made while negotiating a cross-county driving course; and

4. The number and nature of problems related to soldier performance, as well as the number and severity of safety hazards noted.

Soldiers drove with the monocular AN/PVS-14, the binocular AN/AVS-6, and the biocular baseline system (AN/PVS-7D) in a predetermined sequence to equalize the environmental and learning effects between systems. This design ensured that each type of system was used in the same light levels and weather conditions. Two different driving courses were used: hardtop and cross country. Soldiers were instructed to drive the courses as quickly and safely as possible with each type of night vision system.

A total of 15 soldiers participated in the assessment, and they were divided into two subgroups: 5-ton drivers and high mobility multipurpose wheeled vehicle (HMMWV) drivers. Of the five 5-ton truck drivers, four were from the 1st Battalion, 29th Infantry Regiment at Fort Benning, Georgia. The fifth 5-ton driver was from the U.S. Army Engineer Center and School at Fort Leonard Wood, Missouri. Three of the five 5-ton drivers had previous experience driving a vehicle while wearing night vision devices (NVDs). The 10 HMMWV drivers were all from the 988th MP Company at Fort Benning. Five of the HMMWV drivers had previous experience driving vehicles while wearing night vision goggles (AN/PVS-7s).

Findings indicated that the soldiers were able to drive with the AN/PVS-14 MNVDs and the AN/AVS-6s as well, if not better, as they could with the baseline system (AN/PVS-7Ds). No problems surfaced that should preclude safety certification of driving with the night vision devices on terrain similar to that used in the study.

SAFETY ASSESSMENT OF WEARING THE AN/PVS-14 MONOCULAR NIGHT VISION DEVICE (MNVD) AND AN/AVS-6 AVIATOR'S NIGHT VISION IMAGING SYSTEM (ANVIS) DURING 5-TON AND HMMWV NIGHT DRIVING

1. Introduction

1.1 Purpose

The purpose was to obtain safety certification for soldiers driving with the AN/PVS-14 monocular night vision device (MNVD) and the AN/AVS-6 aviator's night vision imaging system (ANVIS). The Communications-Electronics Command (CECOM) Directorate for Safety Risk Management, Fort Monmouth, New Jersey, will use the results of the assessment to determine the suitability of soldiers' wearing the AN/PVS-14 and the AN/AVS-6 while driving.

1.2 Background

The fielding of the AN/PVS-14 has necessitated the requirement of a safety release for driving with the MNVD. A literature search revealed that several experiments have been conducted in which soldiers successfully drove vehicles while wearing monocular devices. One experiment (the night driving concept evaluation program [CEP]) was conducted at Fort Benning, Georgia, to provide a near-term solution for reducing the hazards of night driving with the AN/PVS-7D goggles (biocular), the AN/AVS-6 (binocular), an MNVD, and a holographic goggle. The findings indicated that drivers were able to negotiate a hardtop and a cross-country course while wearing all four types of night vision devices (NVDs). Drivers participating in the CEP experiment of the image intensification (I^2) device field of view (FOV) were able to negotiate both hardtop and cross-country driving courses while wearing MNVDs with FOVs of 32 to 60 degrees. In another CEP experiment (the advance image intensification goggle CEP), drivers were also successfully able to negotiate the driving courses while wearing MNVDs.

The Project Manager, night vision reconnaissance, surveillance, and target acquisition (PM-NV/RSTA) was approached in the second quarter of Fiscal Year 1999 by a unit from the National Training Center (NTC) at Fort Irwin, California, which inquired if the ANVIS, AN/AVS-6 was authorized for use as a ground vehicle driving aid. NTC possessed some ANVIS systems and wanted to allow ground troops to use these NVDs while they drove vehicles. Representatives from PM-NV/RSTA conferred with the CECOM Safety Office about the authorization status for the use of ANVIS systems in the driving of ground vehicles. It was determined that this issue had not been evaluated and

that authorization had not been granted. It was known at the time that the AN/PVS-14 monocular NVD would need to undergo evaluation for preparation of a safety assessment to determine its suitability of use as a night driving aid and to receive authorization for that purpose. The PM-NV/RSTA and the CECOM Safety Office agreed that these systems should be evaluated together to determine whether the systems should be authorized for use as night driving aids.

1.3 Issues

1. Does wear of the AN/PVS-14 and AN/AVS-6 have an adverse impact on soldier performance during mounted tactical movement at night?

2. Do any design features of the AN/PVS-14 or the AN/AVS-6 adversely affect soldier safety?

1.4 Measures of Effectiveness

This assessment evaluated the following characteristics of the AN/PVS-14 MNVD and AN/AVS-6 ANVIS via the measures of effectiveness (MOEs) as shown in Table 1.

Table 1. Characteristics and MOEs of the AN/PVS-14 and AN/AVS-6

Characteristics	MOE
Training	The number and nature of training requirements for driving with the AN/PVS-14 MNVD and the AN/AVS-6 ANVIS at night.
Hard surface driving	Time to complete and number of errors committed while one is negotiating the hardtop driving course and wearing each of the NVDs
Cross-country driving	Time to complete and number of errors committed while one is negotiating the cross-country driving course and wearing each of the NVDs.
Human factors engineering (HFE) and safety performance	(1) The number and nature of problems related to soldier performance. (2) The number and severity of safety hazards noted.

2. Method

Table 2 displays the dates, events, vehicles, and locations for the assessment.

Table 2. Schedule of Dates, Events, Vehicles, and Locations

Dates	Event	Type vehicle	Location
10&17 May 99	Training HMMWV drivers	HMMWV	Building 4, Classroom 31
17 May 99	Training 5-ton drivers	5-ton	McKenna[a] classroom
17 May 99	Driving Hardtop	5-ton Truck	McKenna helipad
17 May 99	Driving Cross-country	5-ton Truck	vicinity McKenna airstrip
19-20 May 99	Driving Hardtop	HMMWV	McKenna helipad
19-20 May 99	Driving Cross-country	HMMWV	vicinity McKenna airstrip

[a]The McKenna MOUT site is in Fort Benning.

The night fighting training facility, Building 4, Classroom 31, and the McKenna military operations in urban terrain (MOUT) training facility were used for NVD training. Outdoor driving iterations were conducted in existing light and weather conditions during the hours of darkness. Fort Benning's Lawson Army Airfield provided moon rise, moon set, and percent of illumination data during the assessment (see Table 3). The experimental design ensured that each device was used in the same light levels and weather conditions. The investigating officer established starting and ending times for the high and low light conditions.

Table 3. Moonlight Information

Dates	Percent of illumination	Moon rise	Moon set
17-18 May 99	5	0849	2308
19-20 May 99	19	1050	0008

2.1 Experimental Design

The goal of this study was to examine the safety of driving military wheeled vehicles when soldiers wear NVDs. The independent variables were NVD type, vehicle type, and terrain. There were three NVDs: the monocular AN/PVS-14, the binocular AN/AVS-6 ANVIS, and the biocular AN/PVS-7D, which was used as a baseline. The two vehicle types were high mobility multipurpose wheeled vehicles (HMMWVs) and 5-ton trucks. There were two terrain conditions: hardtop road and cross-country trails. The dependent variables were number of errors (i.e., missed or wrong turns, backups, hit or knocked down cones, etc.) committed on the courses and times to complete the courses. Subjective measures were designed to enable soldiers to express opinions about their experiences when they used the NVDs to drive. These questionnaires consisted of 7-point semantic differential scales (designed to allow the soldiers to rate each of the NVDs for pertinent characteristics and ease of task accomplishment), as well as open-ended questions.

The participants drove with each NVD on both types of courses. Limited resources precluded the generation of a large sample size for all three NVD-vehicle combinations. The sponsors requested that the number of iterations with the HMMWV and AN/PVS-14 combination be at least 30, since it was the primary focus of the assessment. The 5-ton evaluation was intended only to verify that drivers could operate the vehicle while they wore the NVDs. Limited numbers of the AN/AVS-6 ANVIS goggles, different numbers of iterations with the NVD types, and the joint use of participants in another night vision study precluded a truly counterbalanced design. However, the effect of light levels and weather conditions was controlled.

2.2 Participants

Ten enlisted soldiers from the 988th Military Police (MP) Company, Fort Benning, Georgia, were used during the assessment to drive the HMMWV. Four enlisted soldiers from the 1st Battalion, 29th Infantry, Fort Benning, and one enlisted soldier from the U.S. Army Engineer School were used to drive the 5-ton truck. Clothing and equipment used by the soldiers included standard battle dress uniforms with the personal armored system for ground troops (PASGT) helmet.

All soldiers completed a demographic questionnaire designed to elicit information about Army experience, as well as soldier descriptive data. Detailed demographics are presented in Appendix A.

2.2.1 Five-ton Drivers

The sample consisted of two military occupational specialty (MOS) 88M and two MOS 11M drivers from the 1st Battalion, 29th Infantry Regiment, Fort Benning and one MOS 12B driver from the U.S. Army Engineer Center and

School, Fort Leonard Wood, Missouri. Time in service varied from 8 months to 216 months, and rank varied from E-2 to E-7. The male soldiers' height ranged from 76th to 87th percentile and the female soldier's height was in the 50th percentile. Their weights ranged from 31st to 99th percentile (male), and the female's weight was in the 50th percentile. Three of the five had previously used NVDs to drive a military vehicle.

2.2.2 HMMWV Drivers

The soldier sample consisted of seven MOS 95B, one MOS 91B, one MOS 63B, and one MOS 31U drivers from the 988th MP Company, Fort Benning. All drivers were licensed for the assigned vehicle. Time in service varied from 6 months to 92 months and rank from E-2 to E-5. The soldiers' height ranged from 63 to 73 inches (35th to 95th percentile for females and 3rd to 95th for males), and weight varied from 123 to 243 pounds (25th to 70th percentile for females and 10th to 94th for males). Three of the HMMWV drivers had previously used NVDs to drive before this assessment. All the soldiers used the NVDs in an experiment the week before but not for driving. However, this did give them recent experience with the NVDs. Detailed demographic data are presented in Appendix A.

2.3 Apparatus

2.3.1 Experimental Items

The AN/PVS-14 and the AN/AVS-6 evaluated during this assessment used image intensification (I^2) technology. This technology amplifies available light and near infrared radiation and uses third generation technology. Third generation technology systems provide effective imagery in light conditions from full moon to overcast starlight. The AN/PVS-14 is an MNVD with a 40-degree FOV. It is a third generation I^2 device and is designed to be lightweight, compact, and helmet mounted. The AN/AVS-6 ANVIS has a true binocular FOV of 40 degrees. The ANVIS is a third generation I^2 device that has been adapted to fit on the standard PASGT helmet. This modified version of the ANVIS was being evaluated for a specific application in response to a request from the NTC Combat Support Battalion at Fort Irwin, California.

2.3.2 Hardtop (Cone) Course

The hardtop course, which was developed by the Human Research and Engineering Directorate of the U.S. Army Research Laboratory and by Dismounted Battlespace Battle Laboratory (DBBL) personnel, was located on a helipad airstrip at Fort Benning's McKenna MOUT site. The driving course was approximately 150 meters long and was delineated with driver training cones. The cone path width was approximately one and one-half (HMMWV) to two (5-ton) times the width of the vehicle and consisted of several curves, right- and left-hand turns, and one back-up point that forced the drivers to use scanning

techniques to see the direction in which they were turning. A drawing of the hardtop (cone) course is given in Appendix B.

2.3.3 Cross-Country Course

The cross-country driving course was located within the training areas surrounding Fort Benning's McKenna MOUT site. The total length of the course was approximately 4.4 miles and consisted of improved dirt roads, unimproved dirt roads, and off-road portions. An analysis of the U.S. Army Safety Center's ground vehicle accident data summary contained in Ruffner, Piccione, and Woodward (1997, Appendix A) revealed that of the 79 ground vehicle accidents involving AN/PVS-7s, 33% were attributed to "drop-off" obstacles (>3 feet deep), and 29% were attributed to ditches (≤3 feet deep). These were the two primary categories of terrain hazards associated with the accidents. Because of obvious safety concerns, the design of the cross-country driving course did not include drop-offs, but it did include a number of ditches and depressions such as stream beds. (Note: The lack of drop-offs in the course should be taken into consideration when one is contemplating the data for a safety release.) The course also contained several other obstacle types for the drivers to negotiate. Included was a fallen tree across the road that required the driver to detect the tree, turn off the road onto a small path, and maneuver the vehicle between two trees, allowing approximately 2 feet of clearance on either side. Additionally, there were small logs, holes, and sandy ruts in the road. The cross-country course layout is shown in Appendix B. Checkpoints marked with light sticks were used along the route to identify turning points.

2.4 Procedure

2.4.1 Training

Before the first training presentation, soldiers received a roster number that was used to identify them throughout the assessment. The initial training for both the HMMWV and 5-ton drivers took place in a classroom setting. A representative from DBBL presented a classroom course to train the soldiers in the fundamentals of mounted tactical movement at night. During this presentation, the soldiers were also taught the key elements of night vision and I^2 technology, how to focus the NVDs using a visual acuity resolution chart, how to adjust the helmet mount assemblies, and the fundamentals of scanning techniques during movement.

2.4.2 Hardtop Driving (5-ton)

During daylight hours, the soldiers walked and drove the hardtop course to become familiar with the cone layout. Iteration 1 was the nighttime driving familiarization iteration. (Drivers used the AN/PVS-7Ds for familiarization to reduce the effect of the learning curve.) When the investigating officer determined that end-of-evening nautical twilight had occurred, the drivers were given the opportunity to use a resolution chart to properly focus their NVDs. Each driver stood approximately 25 feet from the chart to focus. Data collectors wearing

AN/PVS-7D goggles were assigned as assistant drivers in each vehicle for safety purposes. Each soldier completed the course once while wearing the AN/PVS-14 and once while wearing the AN/AVS-6. Data collectors recorded the time to complete the course, the number of cones hit on the driver's side, the number of cones hit on the passenger's side, and the number of times the driver drove outside the cones or had to back up to correct driving errors. Table 4 shows the hardtop driving iteration matrix for the 5-ton drivers.

Table 4. Five-ton Driving Matrix Hardtop (Cone)

Soldier number	Iteration number 1	2
1	AN/PVS-14	AN/AVS-6
2	AN/AVS-6	AN/PVS-14
3	AN/PVS-14	AN/AVS-6
4	AN/AVS-6	AN/PVS-14
5	AN/PVS-14	AN/AVS-6

2.4.3 Hardtop Driving (HMMWV)

The same procedure used during the 5-ton hardtop exercise was used for the HMMWV hardtop driving. However, the availability of four HMMWVs increased the number of iterations that could be run in an evening, allowing the use of the AN/PVS-7 as a baseline and increased iterations with the AN/PVS-14. Before darkness, the drivers walked and drove the hardtop course so that they had a chance to see what was expected of them. When darkness occurred, the drivers were given the opportunity to use a resolution chart or object to properly focus their NVDs. The drivers stood approximately 25 feet from the chart or an object of their choice to focus. Each soldier completed the course three times with the AN/PVS-14, once with the AN/AVS-6, and once with the AN/PVS-7D NVDs. The number and sequence of iterations were determined by the amount of time and by the numbers of each type of device available. Also, the joint use of participants with another event necessitated that all the AN/PVS-7D driving occur during iterations 4 and 5. Table 5 shows the matrix for the hardtop driving iterations for the HMMWV drivers.

2.4.4 Cross-Country Driving (5-ton)

Data collectors wearing AN/PVS-7D goggles were assigned as assistant drivers for safety purposes. The data collectors drove the cross-country course during daylight hours for familiarization. Each data collector was assigned to a vehicle, and the drivers were assigned a vehicle and sequence order. The matrix showing the sequence order is shown in Table 6. When darkness occurred, the first driver was given the opportunity to use a resolution chart to properly focus his NVD.

The driver stood approximately 25 feet from the chart to focus. After focusing his NVD, the first driver entered the vehicle and departed from the starting point in the direction of Checkpoint 1. Following the same procedure, drivers were sent after the vehicle returned, until the first iteration was complete. When all drivers had finished the first iteration, the course was reversed to give the drivers a different look at the course. This technique was used to reduce the learning curve since only one course was available. At one point on the cross-country course, the drivers were exposed to vehicle headlights to determine the effect on their ability to continue driving, to evaluate the amount of "blooming" (i.e., whiting out of the night vision goggle screen) caused by the headlights, and to determine the effect of the tube-clamping circuit's response to bright light exposure on the ability of the driver to continue operating the vehicle.

Table 5. HMMWV Driving Matrix Hardtop (Cone)

Soldier number	Iteration number 1	2	3	4	5
1	AN/PVS-14	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-7D
2	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D	AN/PVS-14
3	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D
4	AN/PVS-14	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-7D
5	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D	AN/PVS-14
6	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D
7	AN/PVS-14	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-7D
8	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D	AN/PVS-14
9	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D
10	AN/PVS-14	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-7D

Table 6. Five-ton Driving Matrix Cross-Country Course

Soldier number	Iteration number 1	2
1	AN/AVS-6	AN/PVS-14
2	AN/PVS-14	AN/AVS-6
3	AN/AVS-6	AN/PVS-14
4	AN/PVS-14	AN/AVS-6
5	AN/AVS-6	AN/PVS-14

Since previous experimentation has demonstrated that long-term driving with NVDs may cause headaches, eye strain, and other vision problems, all drivers completed the first iteration before they began the second iteration. This allowed sufficient rest between iterations.

2.4.5 Cross-Country Driving (HMMWV)

Data collectors wearing AN/PVS-7D goggles were assigned as assistant drivers for safety purposes. The data collectors drove the cross-country course during daylight hours for familiarization. Each data collector was assigned to a vehicle, and the drivers were assigned a vehicle and sequence order. The matrix showing the sequence order is shown in Table 7. After focusing his NVD, the first driver entered the vehicle and departed from the starting point in the direction of Checkpoint 1. Following the same procedure, drivers were sent in 5-minute intervals after the vehicle returned, until the first iteration was complete. When all drivers had finished the first iteration, the course direction was reversed to give the drivers a different look at the course. It was then reversed for all subsequent iterations. This technique was used to reduce the learning curve because only one course was available. At one point on the cross-country course, the drivers were exposed to vehicle headlights to determine the effect on their ability to continue driving, to evaluate the amount of blooming caused by the headlights, and to determine the effect of the tube-clamping circuit's response to bright light exposure on the ability of the driver to continue operating the vehicle.

Table 7. HMMWV Driving Matrix Cross-Country Course

Soldier number	Iteration number 1	2	3	4	5
1	AN/PVS-14	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-7D
2	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D	AN/PVS-14
3	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D
4	AN/PVS-14	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-7D
5	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D	AN/PVS-14
6	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D
7	AN/PVS-14	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-7D
8	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D	AN/PVS-14
9	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-14	AN/PVS-7D
10	AN/PVS-14	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-7D

Since previous experimentation has demonstrated that long-term driving with NVDs may cause headaches, eye strain, and other vision problems, all drivers completed an iteration before they began subsequent iterations. This allowed rest between iterations.

2.4.6 Human Factors Engineering and Safety

A human factors engineering evaluation (HFEE) was conducted throughout the assessment to identify any problems or concerns related to the soldier-machine interface. The HFEE assessed the following:

a. Design characteristics

b. Equipment impacts on soldier performance

c. Equipment interface and compatibility with other items of soldier clothing and equipment

d. Safety and health hazards

Throughout the assessment, investigators observed the soldiers using the AN/PVS-14 and AN/AVS-6 NVDs. Investigator observations and soldier comments concerning any feature or operating characteristics that made the NVDs difficult, awkward, or unsafe to use or operate were recorded. Particular attention was given to difficulties encountered that were attributable to design characteristics or functional operations of the NVDs.

2.5 Data Collection

For the hard-top driving course, data collectors recorded the time to complete the course, the number of cones hit on the driver's side, the number of cones hit on the passenger's side, and the number of times the driver drove outside the cones or had to back up to correct driving errors. For the cross-country driving course, data collectors collected times to complete the course, numbers of errors, and soldier comments. After each iteration with each NVD and at the conclusion of the assessment, the soldiers answered an HFE questionnaire designed to elicit their opinion of the NVDs based on their experience for that iteration and throughout the evaluation, respectively.

2.6 Data Analysis

Separate paired comparison t-tests were conducted for the 5-ton evaluations (hardtop and cross-country) and separate analyses of variance (ANOVAs) were conducted for HMMWV evaluations (hardtop and cross-country). Paired comparison t-tests and within-subject repeated measures ANOVAs were conducted on the dependent variables (number of errors on the course and time required to complete the course) with the independent variables (NVD type, vehicle type, and terrain). The level of significance for these analyses was 0.05. Holm's sequential Bonferronis were used to control for family-wise error rates in the ensuing paired sample t-tests used when the ANOVA was significant.

2.7 Limitations of Assessment

The original experimental design called for the evaluation of HMMWV driving with the AN/PVS-14 and the AN/PVS-7D as a baseline on both the hardtop and cross-country driving courses. The resources that were obtained for the assessment (i.e., soldier availability, range schedule, number of NVDs, and time allocated to conduct the assessment) were based on the original design. The request by the sponsors to include the AN/AVS-6 goggles and 5-ton truck-driving verification in the assessment necessitated a reduction in the number of iterations with each type of device. The sponsors agreed that it was very

important to include a larger number of iterations of HMMWV driving with the AN/PVS-14, since it was the primary focus of the assessment. Therefore, the number of iterations with conditions other than the AN/PVS-14s and the HMMWVs and the experimental design were not optimal. Also, the small number of AN/AVS-6 devices (three) available and the joint use of soldiers from another NVD experiment affected the order of the NVD presentation for driving with the HMMWV. The availability of only one 5-ton truck and only five licensed drivers also limited the number of iterations run with the truck. However, the purpose of the assessment was for safety certification, not for comparison of the devices via statistical analysis, so these were not considered to be fatal flaws.

3. Results

3.1 Training

All the soldiers reported that the training was adequate and that they were capable of using the systems for night driving operations. There were some initial frustrations with fitting and adjusting the AN/AVS-6 to the PASGT helmet, but with practice and assistance from on-site personnel, soldiers were able to adjust and fit the devices adequately.

The results of the soldiers' evaluation of the training are shown in Appendix C. Using a 7-point semantic differential scale, with 7 being extremely good and 1 being extremely bad, the soldiers thought the training with the NVDs was good to very good. Several soldiers suggested that the practical exercise portion of the training be lengthened. The soldiers found the AN/PVS-7D and AN/PVS-14 to be easy to set up and operate. The AN/AVS-6 was a little more difficult, but the soldiers became proficient with practice. The soldiers unanimously agreed that no changes were needed in the training program for the three systems, other than the inclusion of additional practical exercises.

3.2 Hardtop Course

The total number of cones glanced and knocked down left and right, number of unplanned backups, and number of times soldiers drove off the course (went outside the cone path so that the controller had to reorient them to the course) are shown in Table 8. Although the drivers wearing the AN/PVS-14 on their right eyes reported that seeing cones on the left side of the vehicle was very difficult, they made more errors on the right side. This was more prevalent with the 5-ton because of the vehicle's height. The 5-ton's maneuverability was considerably less than the HMMWV's, but the 5-ton course was wider. The HMMWV drivers used the technique of backing up to correct problems more than the 5-ton drivers did. However, this did not reduce the comparative numbers of driving off course errors. The mean times to complete the courses are shown in Table 9. The 5-ton

drivers recorded a shorter mean time to complete the course as shown in Table 9. This may be partially a result of the number of times the HMMWV drivers backed up to correct errors.

Table 8. Mean Results of Hardtop (Cone) Course

	5-ton		HMMWV		
	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-6	AN/PVS-7D
Cones hit (glanced) on left	0.20	0.00	1.00	0.00	1.00
Cones knocked down left	0.40	0.60	1.00	0.00	1.00
Cones hit (glanced) on right	0.20	0.80	1.50	0.00	1.00
Cones knocked down right	2.00	0.60	1.20	1.50	1.00
Number of backups required	0.20	.00	2.07	1.78	1.57
Number of times off course	0.00	0.20	3.13	4.00	0.00

Table 9. Mean Time to Complete (in minutes) Hardtop (Cone) Course

	5-ton		HMMWV		
	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-6	AN/PVS-7D
Mean time to complete	2.01	2.06	2.45	2.34	3.14

Paired comparison t-tests performed on the 5-ton driver data between the times to complete the hardtop course with the AN/PVS-14 and the AN/AVS-6 revealed no significant difference. There was no significant difference in errors committed. Since the soldiers who drove the HMMWV drove the course with the AN/PVS-14 three times and one time with the other NVDs, the mean of the AN/PVS-14 times and errors for each individual was entered into the statistical program. A repeated measures ANOVA revealed no significant difference between the NVDs in terms of time to complete the course. There was no significant difference between the NVDs in terms of errors committed on the course.

Table 10 shows the mean of the soldiers' responses pertaining to their ability to complete night driving tasks with the NVDs and their ratings of the NVD characteristics using a 7-point semantic differential scale with 7 being the highest/best. The complete results of the tasks and characteristics are presented in Appendix C. The soldiers found all NVDs to be better than neutral in all task areas and in all characteristic areas evaluated. The drivers had some difficulty judging angles and driving backward with the AN/AVS-6. They also had difficulty adjusting the AN/AVS-6 to the helmet. Two soldiers mentioned the "flimsy" nature of the helmet mount. They had to continuously adjust the helmet and NVDs on their heads. The soldiers had the same difficulty backing up with the AN/PVS-14 and the AN/PVS-7D. They mentioned having to become accustomed to the monocular design of the AN/PVS-14 (i.e., using only one eye while driving), but experience with the goggle seemed to help. This was evidenced in the learning curve present in the AN/PVS-14 driving data. The soldiers were advised to turn the gain as low as possible on the AN/PVS-14 to allow a better chance for their other eye's natural night vision.

Table 10. Mean Results of Tasks and Characteristics Traversing the Hardtop (Cone) Course

	5-ton		HMMWV		
	AN/PVS-14	AN/AVS-6	AN/PVS-14[a]	AN/PVS-6	AN/PVS-7D
Tasks	3.52	4.93	4.52	4.90	4.26
Characteristics	4.36	4.88	5.02	5.24	4.21
Overall rating	4.00	5.40	4.50	5.90	4.24

[a]Means include data from three AN/PVS-14 iterations.

A paired comparison t-test was performed on the overall ratings of the AN/PVS-14 compared to the AN/AVS-6. For 5-ton drivers, there was no significant difference. However, this result may have been affected by the small sample size (N = 5). A one-way ANOVA was run on the HMMWV drivers' overall ratings for the AN/PVS-7D, the AN/PVS-14, and the AN/AVS-6. Ensuing Holms sequential Bonferroni tests revealed no significant difference between goggle pairs.

After driving the hardtop course with the AN/PVS-14, drivers reported eye strain in 5 of 30 iterations, lens fogging four times, tunnel vision two times, disorientation two times, and headache one time. Many soldiers reported that they were not accustomed to the monocular design of the AN/PVS-14. Four of five of the reports of eye strain were during the first iteration of driving with the AN/PVS-14. The fifth report was by a different soldier after his second iteration with the monocular. By the third iteration, there were no reports of eye strain. When soldiers complained of eye strain with the AN/PVS-14, they were

instructed to reduce the gain of the device so that there was not as much contrast between the light levels entering the aided and unaided eye. There were no cases of reported eye strain from the soldiers in subsequent AN/PVS-14 iterations after they received and complied with these instructions. The eyecup on the MNVD contributed to the fogging. Once soldiers started folding back their eyecups, they had fewer problems with fogging. After driving with the AN/PVS-7D, soldiers reported tunnel vision once, headaches three times, and disorientation once in ten driving iterations. The soldiers experienced fewer symptoms when they wore the AN/AVS-6; there were only single reports of tunnel vision and headache.

Several of the soldiers found it difficult to view objects around the chemical safety light sticks used for safety and control. On one occasion, a soldier wearing the AN/PVS-14 was exposed to an unplanned flash of headlights from a civilian vehicle. He reported blurred vision and temporary loss of all night vision. The driver was one of the least experienced and admitted to staring directly into the headlights as opposed to using scanning and off-sight techniques. This resulted in the natural night adaptation of the unaided eye being interrupted. The Directorate for Safety Risk Management did not consider this a safety issue related to the NVDs but rather a training issue.

The unaided eye of the AN/PVS-14 wearers appeared to provide a lot less benefit for drivers than it does for dismounted troops (because of the distance from the eye to the ground in front of the vehicle). However, experienced drivers were able to use the unaided eye for other tasks. The unaided eye appeared to provide no benefit to inexperienced goggle wearers. No safety concerns surfaced during the hardtop course to indicate that the NVDs were not safe for driving. The complete results of the questionnaires and comments collected during the hardtop driving are given in Appendix C.

3.3 Cross-Country Course

The results of the soldiers' driving abilities with the NVDs are shown in Table 11, and their mean times to complete the course are shown in Table 12.

Table 11. Mean Results of the Cross-Country Course

	5-ton		HMMWV		
	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-6	AN/PVS-7D
Missed turns left	0.00	0.00	1.50	0.00	0.00
Missed turns right	0.00	0.00	1.25	1.00	1.00
Number of backups required	1.00	1.40	1.63	1.00	1.00

Table 12. Mean Time to Complete (in minutes) Cross-Country Course

	5-ton		HMMWV		
	AN/PVS-14	AN/AVS-6	AN/PVS-14	AN/PVS-6	AN/PVS-7D
Mean time to complete	20.58	22.75	16.56	16.03	14.10

Paired comparison t-tests on the 5-ton driver data between the times to complete the cross-country course with the AN/PVS-14 and the AN/AVS-6 revealed no significant difference. There was no significant difference in errors committed.

Since soldiers drove the course in the HMMWV with the AN/PVS-14 three times and the other NVDs one time, the mean of the AN/PVS-14 times and errors for each individual was entered into the statistical program. A repeated measures ANOVA revealed a significant difference between the NVDs in terms of time to complete the course ($p < .02$). When paired comparison t-tests were performed and a Holms sequential Bonferroni was used to control for family-wise error, there was no significant difference between the AN/PVS-14 and the AN/AVS-6. However, there was a significant difference between the AN/PVS-7D and the AN/PVS-14 ($p < .01$), and the AN/AVS-6 and the AN/PVS-7D comparison approached significance ($p = .051$). A repeated measures ANOVA was then used to investigate whether the presentation order had an effect on the outcome of the comparison. The order effect was significant ($p < .01$). The order effect appears to be caused by the fact that two of the AN/PVS-14 runs and the AN/AVS-6 runs occurred in the first three iterations and all the AN/PVS-7D runs occurred in the fourth and fifth iterations. When a repeated measures ANOVA was run with the last AN/PVS-14 iterations rather than the mean of the AN/PVS-14, there were no significant differences among the soldiers' performance with the three NVDs.

A repeated measures ANOVA revealed that no significant difference in errors was made with the three NVDs. No order effect was found on number of errors made.

Table 13 presents the results of the soldiers' ratings of their ability to perform driving tasks with the NVDs and the characteristics of the NVDs. The soldiers found all NVDs to be better than neutral in all task and characteristics evaluated. Several soldiers reported difficulty with the head mounts. One mentioned that the goggle was "bouncy" on his head.

A paired comparison t-test was performed on the overall ratings of the AN/PVS-14 compared to the AN/AVS-6. For 5-ton drivers, there was no

significant difference. A one-way ANOVA was run on the HMMWV drivers' overall ratings for the AN/PVS-7D, the AN/PVS-14, and the AN/AVS-6, and it was significant ($p < .05$). However, when a Holms sequential Bonferroni was used to control for ensuing repeated t-tests, no comparison was significant at the .05 level.

Table 13. Mean Results of Tasks and Characteristics Traversing the Cross-Country Course

		5-ton	HMMWV		
	AN/PVS-14	AN/AVS-6	AN/PVS-14[a]	AN/PVS-6	AN/PVS-7D
Tasks	3.94	4.77	4.70	5.13	4.69
Characteristics	4.52	4.42	4.74	5.28	4.17
Overall rating	4.23	4.60	4.72	5.21	4.43

*Means include data from three AN/PVS-14 iterations.

The soldiers felt comfortable driving the course at speeds of more than 20 miles per hour (mph) with all three NVDs. Several soldiers commented they were confident with driving faster than 30 mph except around sharp turns. (The Directorate for Safety Risk Management had limited the speed to 30 mph on roads.)

The extended wear time (13 to 25 minutes) with the NVDs on the cross-country mounted course revealed more problems than the comparatively short period while soldiers participated in the hardtop (cone) course. However, the soldiers did not believe any of the symptoms they experienced would keep them from accomplishing the task of driving at night. During this evaluation, the soldiers experienced problems with all three NVDs. Table 14 displays the frequency of problems as a percentage of driving iterations in which the drivers experienced each of the problems. Percentages were reported rather than total numbers of problems because there were more iterations with the AN/PVS-14 than there were with the other NVDs. The AN/PVS-14s caused more eye strain than either of the other NVDs, but it is interesting to note that drivers experienced fewer headaches with it.

On 16 occasions (of 30 iterations), the soldiers wearing AN/PVS-14s reported blooming. On 10 of 15 occasions, the soldiers reported the same problem with AN/AVS-6s, and on seven of ten occasions, they reported the same problem with the AN/PVS-7D. When asked if the exposure to the vehicle headlights interfered with their ability to maintain control, most indicated that they experienced no problems. Soldiers using the AN/PVS-14 reported they had to either decelerate or stop to readjust/reorient themselves, and once they adjusted the gain, they were able to continue. They also reported using their non-aided eye

to drive through the bright lights. This was accomplished by closing the aided eye. Those drivers using the AN/AVS-6 appeared to be able to adjust quickly also. One stated that the exposure did not bother him as much as with the other devices, and he was able to drive through the bright light exposure. Others decelerated and adjusted to the light. This could be a result of the output brightness on the AN/AVS-6 being set lower at the factory.

Table 14. Percentage of Problem Areas Reported

	AN/PVS-14	AN/PVS-7D	AN/AVS-6
Eye strain	0.43	0.30	0.20
Tunnel vision	0.20	0.10	0.07
Headaches	0.14	0.30	0.27
Motion sickness	0.00	0.00	0.00
Screen white-out	0.14	0.00	0.00
Nausea	0.00	0.00	0.00
Disorientation	0.11	0.10	0.13
Dizziness	0.03	0.10	0.07
Lens fogging	0.17	0.10	0.07
Other	0.03	0.00	0.07
Reported problems during driving iterations	1.13 per iteration	1.4 per iteration	1.3 per iteration

The helmet mounts presented some problems with all the NVDs. Some of this difficulty was attributable to the soldiers' inability to correctly adjust their individual helmets. There was also a counterbalance problem because of the weight distribution of the NVDs (all weight was on the front of the helmet). Perhaps the use of the parachutist's nape strap on the PASGT helmet would alleviate some of this counterbalance problem. This problem appeared to be more severe with the female soldiers who had smaller heads and faces.

All NVDs were found to be neutral to very good in the areas evaluated by the soldiers during the cross-country driving course. There were no indications that any of the NVDs might be unsafe for use in the driving of tactical vehicles at night in typical cross-country missions. Individual responses to the questionnaires and soldier comments are presented in Appendix C.

3.4 Human Factors Engineering and Safety

The systems evaluated for the safety certification are both fielded systems. The AN/AVS-6 has been in use in Army aviation for more than a decade, and the AN/PVS-14 is a more recent acquisition for ground troops. The design

characteristics have been evaluated in the past on numerous occasions. The AN/AVS-6 PASGT mount is not adequate for attachment to the PASGT helmet and therefore is not adequate for use by drivers of military vehicles. The battery pack, intended as a counterbalance system, does not have an adequate method of attachment to the PASGT. Additionally, the battery pack has to be placed to one side of the rear of the PASGT helmet to preclude interference with the mounting strap. A more secure means of attaching the counterbalance needs to be designed.

Counterbalances were not offered for the AN/PVS-14 or AN/PVS-7D when the PASGT helmet mount was used. The soldiers had difficulty in maintaining stability with the system mounted on the PASGT. The use of the parachutist's nape strap would provide more stability by adding the additional third anchor point on the helmet.

With the current lighting used on military ground vehicles, it is impossible to read the instruments. The soldier must rely on the assistant driver or turn off the NVDs to read the instruments. The AN/PVS-14 allows the best potential to read instruments but requires specific training. When using the AN/PVS-14, the soldier needs to be taught to turn the brightness (gain) down as low as possible. This will allow more effective use of his unaided eye. With the brightness (gain) tuned to the maximum, the unaided eye is overwhelmed and the soldier experiences a "blind eye." If soldiers are properly trained, the incidents of blind eye can be overcome or diminished. They can be taught to use the unaided eye when exposed to bright headlights or other bright lights. Additionally, they can be taught to use their unaided eye to read vehicle gauges. If soldiers are taught how to properly use scanning techniques, then they will be able to take advantage of the 40-degree FOV and use the unaided eye to scan as much FOV as needed when driving. The AN/PVS-14's gain control also allows the user to turn the brightness down in order to use the unaided eye for close in work (such as reading vehicle gauges). The training doctrine for night driving with the AN/PVS-14 NVDs needs to include the training issues noted before. Proper training and practice while soldiers drive with the AN/PVS-14 should greatly reduce any problems reported. The complete results of the soldiers' responses to the human factors questions are given in Appendix C.

There were no observed or reported safety incidents during this evaluation. There was no indication that driving with the AN/AVS-6 or AN/PVS-14 is any less safe than driving with the AN/PVS-7D. No health hazards were noted during this evaluation.

4. Conclusions

The AN/PVS-14 MNVDs and the AN/AVS-6 NVDs are safe for hardtop and cross-country HMMWV and 5-ton driving on terrain no more severe than that used in this study.

Fogging of the lenses and stability of the head and helmet mounts need to be addressed.

5. Recommendation

A safety release needs to be issued for soldiers driving on terrain similar to that used in this study and wearing the AN/PVS-14 MNVDs and the AN/AVS-6 NVDs.

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Reference

Ruffner, J.W., Piccione, D., & Woodward, K. (1997). *Development of a night driving training aide concept, Phase I A96-176a* (DCS-SBIR-97-3106). Alexandria, VA: DCS Corporation.

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APPENDIX A

DEMOGRAPHIC QUESTIONNAIRE RESULTS

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DEMOGRAPHIC QUESTIONNAIRE RESULTS

HMMWV DRIVERS

SAMPLE SIZE = 10

1. Do you smoke? 4 Yes 6 No

2. Do you wear prescription lenses? 5 Yes 5 No

   a. If yes, which do you most often wear?
   2 Glasses 2 Contacts 1 Both

   b. Which do wear while firing a weapon?
   2 Glasses 2 Contacts 1 Both

3. With which hand do you most often write?
   8 Right 2 Left

4. With which hand do you most often fire a weapon?
   8 Right 2 Left

5. What is your height?

   63 inches - 2 68 inches - 2
   64 inches - 1 69 inches - 1
   65 inches - 1 71 inches - 1
   66 inches - 1 73 inches - 1

6. What is your weight?

   120-129 pounds - 1
   130-139 pounds - 1
   140-149 pounds - 3
   150-159 pounds - 1
   170-179 pounds - 2
   180-189 pounds - 1
   210-219 pounds - 1

7. What was your last M16 qualification rating:

   1 Expert 2 Sharpshooter 6 Marksman
   1 Unqualified

8. Have you ever bore sighted an aiming light before?

   6 No
   4 Yes. What type? 4 PAQ-4C 4 AIM-1

9. Have you received previous training on firing with aiming lights?

   7 No
   3 Yes

10. Have you previously used any of the following night vision devices?

	No	Yes
TWS	10	0
AN/PVS-4	10	0
AN/TVS-5	5	5
AN/PVS-5	8	2
AN/AVS-6	10	0
AN/PVS-7A	10	0
AN/PVS-7B	4	6
Other	10	0

5-TON DRIVERS

SAMPLE SIZE = 5

1. Do you smoke? 0 Yes 5 No

2. Do you wear prescription lenses? 0 Yes 5 No

3. With which hand do you most often write? 5 Right 0 Left

4. What is your height? 64 inches - 1
71 inches - 2
72 inches - 2

5. What is your weight? 130-139 pounds - 1
160-169 pounds - 1
190-199 pounds - 2
240-249 pounds - 1

6. Have you ever drove a military vehicle using night vision goggles?

2 No
3 Yes

7. Have you previously used any of the following night vision devices, in any capacity?

	No	Yes
TWS	4	1
AN/PVS-4	4	1
AN/TVS-5	4	1
AN/PVS-5	3	2
AN/AVS-6	5	0
AN/PVS-7A	5	0
AN/PVS-7B	3	2
Other	5	0

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APPENDIX B

DRIVING COURSES HARDTOP (CONE) AND CROSS-COUNTRY

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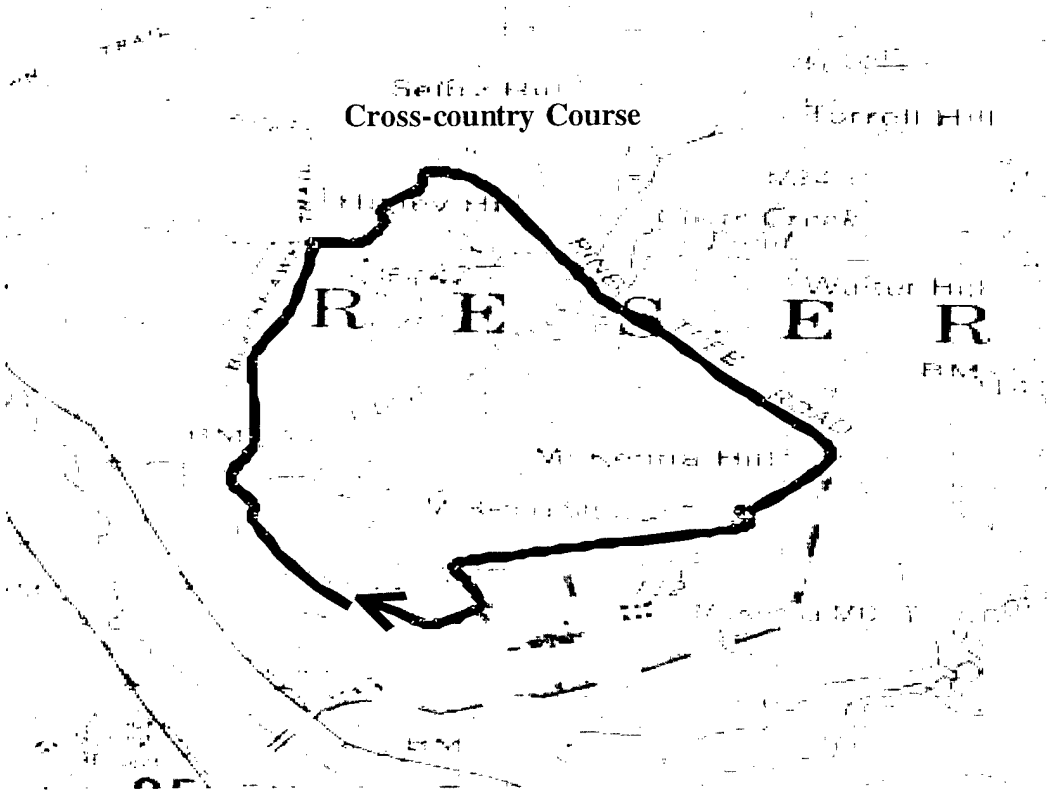
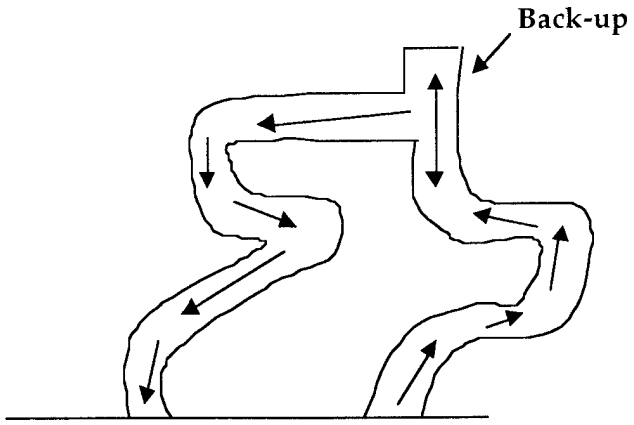
DRIVING COURSES HARDTOP (CONE) AND CROSS-COUNTRY





Hard Top (Cone) Course

Not to scale

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APPENDIX C

HUMAN FACTORS ENGINEERING QUESTIONNAIRE RESULTS

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HUMAN FACTORS ENGINEERING QUESTIONNAIRE RESULTS

DEVICES: AN/AVS-6, AN/PVS-14, AN/PVS-7

VEHICLE DRIVEN/SAMPLE SIZE:
HMMWV (AN/AVS-6, AN/PVS-7) = 10
HMMWV (AN/PVS-14) = 30
5-TON (AN/AVS-6, AN/PVS-14) = 5

HARDTOP (CONES) EXERCISE

1. Please rate your ability to perform the following tasks with the night vision goggle (NVG) you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

	MEAN RESPONSE				
	AN/AVS-6		AN/PVS-14		AN/PVS-7
	HMMWV	5-TON	HMMWV	5-TON	HMMWV
a. See cones on right.	5.50	5.75	4.73	4.20	4.70
b. See cones on left.	5.70	5.75	5.03	3.20	5.10
c. Judge correct turning angle.	5.10	5.75	4.47	3.40	4.90
d. Anticipate terrain ahead.	5.30	5.60	4.90	3.80	4.60
e. Drive forward.	6.00	5.80	5.53	4.60	5.50
f. Drive backwards.	4.70	5.00	4.30	3.00	4.00
g. Reading vehicle gauges.	2.75	3.00	2.40	3.00	2.14
h. Use vehicle mirrors.	3.71	4.20	3.59	2.80	3.25
i. Focus adjustment.	5.11	4.20	5.22	3.60	4.56
j. Diopter adjustment.	5.11	4.20	5.22	3.60	3.83

Comments	No. of Responses
AN/AVS-6 (HMMWV)	
Judging correct angles is very hard due to eye strain with focus adjustment. Driving backwards is almost impossible to see due to goggles being very flimsy.	1
AN/PVS-14 (HMMWV)	
Backing up is harder; can't see the mirror.	1
Judging turning angles is harder.	1
Getting used to the goggles while driving.	1
AN/PVS-7 (HMMWV)	
Too awkward to use for backing up.	1

2. Please rate the following characteristics of the NVG you used.

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

	MEAN RESPONSE				
	AN/AVS-6		AN/PVS-14		AN/PVS-7
	HMMWV	5-TON	HMMWV	5-TON	HMMWV
a. Field-of-view.	5.70	5.20	4.73	4.20	4.90
b. Sight picture clarity.	5.40	5.80	5.27	4.60	4.70
c. Sight picture brightness.	5.30	5.60	5.53	4.80	5.00
d. Anticipate terrain ahead.	5.60	5.20	5.00	4.00	4.50
e. Head mount balance.	5.10	4.60	4.80	4.60	4.20
f. Comfort.	4.90	4.20	4.83	4.00	3.40
g. Device weight.	4.60	4.20	5.30	4.40	3.30
h. Device shape.	5.30	4.60	5.10	4.40	3.60
i. Control design.	5.00	4.40	5.13	4.40	4.30
j. Vehicle compatibility.	5.50	5.00	4.53	4.20	4.20

Comments	No. of Responses
AN/AVS-6 (HMMWV)	
Field-of-view is still only 40 degrees. Goggles are kind of dim, balance on Kevlar is very touchy.	1
AN/PVS-14 (HMMWV)	
Head mount bounces; not secure enough.	3
Head mount balance is front heavy.	1
Field-of-view is not as good.	1

3. Did you notice any reflection from another team member's NVG?

AN/AVS-6 (HMMWV)

0 Yes
10 No

Not around others.	1

AN/AVS-6 (5-TON)

1 Yes
3 No
1 NR

But not bad.	1

AN/PVS-14 (HMMWV)

0 Yes
29 No
1 NR

Not around others.	4

AN/PVS-14 (5-TON)

1 Yes
4 No

Other NVG was on passive, reflections.	1

AN/PVS-7 (HMMWV)

0 Yes
10 No

Going forward worked well.	1
Not around others.	2

4. Do you feel that you had good situational awareness during this exercise (i.e., that you were aware of what was going on around you)?

AN/AVS-6 (HMMWV)

9 Yes
1 No

Hard to see cones with goggles, brightness dimmer than most goggles.	1
Cones were difficult to understand.	1

AN/AVS-6 (5-TON)

5 Yes
0 No

They were outstanding.	1

AN/PVS-14 (HMMWV)

25 Yes
5 No

Cones were hard to see.	2
Cones were confusing.	1
Limited field-of-view.	1
No depth perception.	1

AN/PVS-14 (5-TON)

3 Yes
2 No

I knew where I was.	1
Very hard to judge.	1

AN/PVS-7 (HMMWV)

9 Yes
1 No

Cones were a little confusing.	1
Limited field-of-view.	1

5. What percent of the time did you use your aided vision rather than your unaided vision?

	AN/AVS-6		AN/PVS-14		AN/PVS-7
	HMMWV	5-TON	HMMWV	5-TON	HMMWV
a. 25 percent or less	2	0	1	1	0
b. 26-50 percent	0	0	4	2	0
c. 51-75 percent	0	0	9	0	2
d. 76-100 percent	8	5	16	2	8

6. At what speed would you feel comfortable driving on the cone course with this NVG?

	AN/AVS-6		AN/PVS-14		AN/PVS-7
	HMMWV	5-TON	HMMWV	5-TON	HMMWV
a. 0-3 mph	0	0	2	1	2
b. 4-6 mph	5	1	12	2	4
c. 7-9 mph	3	1	1	0	2
d. 10 mph and over	2	2	5	2	2

AN/AVS-6 (5-TON)

Training makes up difference in devices.	1

AN/PVS-14 (5-TON)

Training makes up difference in devices.	1

7. Did you experience any of the following?

	AN/AVS-6*		AN/PVS-14*		AN/PVS-7*
	HMMWV	5-TON	HMMWV	5-TON	HMMWV
a. Eye strain	0	0	3	2	0
b. Tunnel vision	1	0	3	0	1
c. Headaches	0	1	0	1	3
d. Motion sickness	0	0	0	1	0
e. Screen white out	0	0	0	0	0
f. Nausea	0	0	0	0	0
g. Disorientation	0	0	0	2	1
h. Dizziness	0	0	0	0	0
i. Lens fogging	0	0	6	0	0
j. Other	0	0	0	0	1

*Sample size for AN/AVS-6 : HMMWV = 10; 5-TON = 5
AN/PVS-14: HMMWV = 30; 5-TON = 5
AN/PVS-7 : HMMWV = 10

AN/PVS-14 (HMMWV)

Humidity plus sweat equals fogging. 1

AN/PVS-14 (5-TON)

Just getting used to NVGs. 1

AN/PVS-7 (HMMWV)

Humidity plus sweat equals fogging. 1
The eyepieces don't fit close enough together for one sight picture. They don't come down far enough to fit in front of eye. 1

8. During this exercise, did you experience "blooming" of the goggles?

AN/AVS-6 (HMMWV)

1 Yes
9 No

Only with chem lights. 2

AN/AVS-6 (5-TON)

0 Yes
5 No

AN/PVS-14 (HMMWV)

3 Yes
27 No

Vehicle driving in. 1
Chem lights. 1

AN/PVS-14 (5-TON)

1 Yes
4 No

Objects around lights hard to see. 1

AN/PVS-7 (HMMWV)

0 Yes
10 No

9. If yes, how much did the "blooming" interfere with your exercise?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	low

MEAN RESPONSE

AN/AVS-6		AN/PVS-14		AN/PVS-7
HMMWV	5-TON	HMMWV	5-TON	HMMWV
4.67	3.33	4.25	2.00	NR

AN/PVS-14 (HMMWV)

No blooming. 1
Lost almost all night vision. 1
Peripheral vision not very good; could see in front of me. 1

AN/PVS-7 (HMMWV)

Peripheral vision not very good; could see in front of me. 1

10. During this exercise, were you exposed to bright light while driving and wearing the NVGs?

AN/AVS-6 (HMMWV)

0 Yes
10 No

Not exposed. 1

AN/AVS-6 (5-TON)

2 Yes
3 No

Headlights; chem lights. 1

AN/PVS-14 (HMMWV)

1 Yes
29 No

AN/PVS-14 (5-TON)

1 Yes
4 No

Chem lights; headlights. 1

AN/PVS-7 (HMMWV)

0 Yes
10 No

11. If yes, were you able to maintain control of your vehicle?

AN/PVS-14 (HMMWV)

7 Yes
1 No
22 NR

Vehicle lights were very bright and my eyes blurred. 1

Don't recommend for obstacle driving. 1

AN/PVS-7 (HMMWV)

1 Yes
9 No

12. During this exercise, did the NVG shut down due to high light exposure?

AN/AVS-6 (HMMWV)

0 Yes
9 No
1 NR

None exposed. 1

AN/AVS-6 (5-TON)

0 Yes
4 No
1 NR

There should be more off-road testing instead of cone courses. 1

AN/PVS-14 (HMMWV)

0 Yes
30 No

Not exposed. 2

AN/PVS-14 (5-TON)

0 Yes
4 No
1 NR

AN/PVS-7 (HMMWV)

0 Yes
10 No

13. What is your overall rating of the device you used for driving?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE

AN/AVS-6		AN/PVS-14		AN/PVS-7
HMMWV	5-TON	HMMWV	5-TON	HMMWV
5.90	6.00	4.73	4.40	4.30

AN/AVS-6 (HMMWV)

Best yet. 1

AN/PVS-14 (HMMWV)

Getting easier to use. 1
Depth perception is better driving than walking. 1
For me being right eye dominant, seeing the left side was easier than seeing the right side. 1
Harder to see left and right. 1
Depth perception off a little. 1

AN/PVS-7 (HMMWV)

Harder to see left and right. 1
Depth perception is off a little. 1

CROSS-COUNTRY EXERCISE

1. Please rate your ability to perform the following tasks with the night vision goggle (NVG) you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

	MEAN RESPONSE				
	AN/AVS-6		AN/PVS-14		AN/PVS-7
	HMMWV	5-TON	HMMWV	5-TON	HMMWV
a. Navigate	5.50	5.20	5.13	4.00	5.00
b. Identify inclines	5.70	4.80	4.90	3.60	5.20
c. Identify side slopes	5.20	5.00	4.47	3.20	4.90
d. Identify holes	5.00	4.40	4.47	2.80	4.70
e. Identify ditches	5.20	4.80	4.40	3.00	4.50
f. Identify standing water	5.70	4.60	5.27	3.60	5.40
g. Identify sand	5.20	4.80	4.77	4.80	4.80
h. Identify grassy areas	5.10	5.00	4.80	4.60	5.00
i. Identify rocky area	5.10	5.00	4.53	4.20	4.70
j. Identify vegetation	5.70	5.00	4.73	5.00	4.90
k. Perform terrain driving	5.60	5.20	5.27	4.60	5.10
l. Anticipate terrain ahead	5.50	5.20	4.80	3.80	4.90
m. Drive forward	6.30	5.20	5.50	4.80	5.50
n. Drive backwards	5.00	4.80	4.64	4.00	4.30
o. Read vehicle gauges	3.38	3.75	2.81	1.67	2.14
p. Use vehicle mirrors	3.71	4.40	3.73	3.60	3.25
q. Focus adjustment	4.75	4.40	5.26	4.80	4.33
r. Diopter adjustment	4.67	4.40	5.22	4.80	4.00

2. Please rate the following characteristics of the NVG you used.

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

	MEAN RESPONSE				
	AN/AVS-6		AN/PVS-14		AN/PVS-7
	HMMWV	5-TON	HMMWV	5-TON	HMMWV
a. Field-of-view	5.90	5.00	4.40	4.40	4.90
b. Sight picture clarity	5.70	5.00	4.90	4.20	4.90
c. Sight picture brightness	5.30	5.20	5.17	4.60	4.90
d. Depth perception	5.60	4.40	4.07	4.00	4.30
e. Head mount balance	5.00	4.00	4.43	4.80	3.90
f. Comfort	5.00	3.80	4.60	4.60	3.20
g. Device weight	4.90	4.88	5.13	5.00	3.10
h. Device shape	5.10	4.60	5.00	4.80	3.70
i. Control design	5.10	4.20	5.13	4.80	4.50
j. Vehicle compatibility	5.20	4.80	4.57	4.00	4.30

AN/PVS-14 (HMMWV)

Hard to see on left side of vehicle because no left peripheral vision and blind spot.	2
PVS-14s worn on left eye.	1
Head mount balance is bad.	2
Depth perception not as good as the NVGs.	1
Field-of-view is bad for driving.	4
Couldn't see well even with using the gain control.	1

AN/PVS-7 (HMMWV)

Better head mount balancing would make it easier to drive.	1
Field-of-view is only 40 degrees.	2
Depth perception is better driving than walking.	1
Brightness needs to be able to adjust like the PVS-14s.	1

3. Do you feel that you had good situational awareness during this exercise (i.e., that you were aware of what was going on around you)?

AN/AVS-6 (HMMWV)

9 Yes
1 No

AN/AVS-6 (5-TON)

5 Yes
0 No

Very easy compared to the AN/PVS-14s. 1

AN/PVS-14 (HMMWV)

27 Yes
3 No

Aware of driving, but not of terrain. 1

Could see everything around me. 1
Missed turns. 1
Hard to see in very wooded areas (dark). 1
Limited field-of-view. 1

AN/PVS-14 (5-TON)

4 Yes
1 No

Hard to judge terrain. 1

AN/PVS-7 (HMMWV)

9 Yes
1 No

4. What percent of the time did you use your aided vision rather than your unaided vision?

	AN/AVS-6		AN/PVS-14		AN/PVS-7
	HMMWV	5-TON	HMMWV	5-TON	HMMWV
a. 25 percent of less	0	0	2	0	0
b. 26-50 percent	0	0	3	0	0
c. 51-75 percent	1	0	9	2	2
d. 76-100 percent	9	4	16	3	8

AN/AVS-6 (HMMWV)

Lighter the areas, easier to use the naked eye. 1

AN/PVS-14 (HMMWV)

When the lights came on, I had to use my unaided eye. 1

5. At what speed would you feel comfortable driving on the cross-country course with this NVG?

	AN/AVS-6		AN/PVS-14		AN/PVS-7
	HMMWV	5-TON	HMMWV	5-TON	HMMWV
a. 0-10 mph	1	1	0	1	1
b. 11-20 mph	2	0	11	2	2
c. 21-30 mph	5	2	13	1	3
d. 31 mph and over	2	1	6	1	4

AN/PVS-14 (HMMWV)

Over 31, except around sharp turns. 1

6. Were you able to judge clearance distance between your vehicle and other vehicles?

AN/AVS-6 (HMMWV)

6 Yes
2 No
2 NR

They were very clear and easy to pick up on turns and terrain. 1
Not around other vehicles. 1

AN/AVS-6 (5-TON)

4 Yes
0 No
1 NR

If his lights were off. 1

AN/PVS-14 (HMMWV)

16 Yes
7 No
7 NR

Once I was used to the course. 1
Not very good. 1
Not around other vehicles. 2
Some points of clearance you can see from the moonlight. 1

AN/PVS-14 (5-TON)

4 Yes
1 No

Hard to judge distance. 1

AN/PVS-7 (HMMWV)

6 Yes
2 No
2 NR

No other vehicles on the course. 1
Objects are closer than what they seem. 1

7. Were you able to judge clearance distance between your vehicle and obstacles?

AN/AVS-6 (HMMWV)

9 Yes
1 No

AN/AVS-6 (5-TON)

4 Yes
0 No
1 NR

AN/PVS-14 (HMMWV)

24 Yes

5 No
1 NR

The moonlight helped in some areas.	1
Not very good.	1
Had some trouble between trees (telling distance).	2
At times no, when it got darker in areas.	1

AN/PVS-14 (5-TON)

4 Yes
1 No

AN/PVS-7 (HMMWV)

9 Yes
1 No

8. Did you experience any of the following?

	AN/AVS-6*		AN/PVS-14*		AN/PVS-7*
	HMMWV	5-TON	HMMWV	5-TON	HMMWV
a. Eye strain	2	1	12	3	3
b. Tunnel vision	1	0	5	2	1
c. Headaches	2	2	4	1	4
d. Motion sickness	0	0	0	0	0
e. Screen white out	0	0	5	0	0
f. Nausea	0	0	0	0	0
g. Disorientation	2	0	3	1	1
h. Dizziness	1	0	1	0	1
i. Lens fogging	1	0	6	0	1
j. Other	1	0	1	0	0

*Sample size for AN/AVS-6 : HMMWV = 10; 5-TON = 5
AN/PVS-14: HMMWV = 30; 5-TON = 5
AN/PVS-7 : HMMWV = 10

AN/AVS-6 (HMMWV)

Needs brighter sight picture to see in the darker areas.	1

AN/PVS-14 (HMMWV)

Vehicle lights. Both eyes were fixed and still saw the bar in the middle.	1
Lot of fogging and eyes getting blurry.	1
Had to strain right eye to focus better.	1
When hitting brakes after going too fast.	1
When staring too hard at the road.	1
When lights flashed into eyes.	1
Right eye was really tired.	1

9. During this exercise, did you experience "blooming" of the goggles?

AN/AVS-6 (HMMWV)

7 Yes
2 No
1 NR

Bright lights.	1
Truck lights.	1

AN/AVS-6 (5-TON)

3 Yes
2 No

In the lights of other vehicles, headlights bloom; short duration, good recovery.	1

AN/PVS-14 (HMMWV)

23 Yes
7 No

When truck turned on lights.	15
Eyes blurred.	1

AN/PVS-14 (5-TON)

2 Yes
3 No

Totally blinded by headlights. Able to use unaided eye; bad glare.	1

AN/PVS-7 (HMMWV)

7 Yes
3 No

Only from the truck lights and chem lights.	7

10. If yes, how much did the "blooming" interfere with your exercise?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	low

MEAN RESPONSE

AN/AVS-6		AN/PVS-14		AN/PVS-7
HMMWV	5-TON	HMMWV	5-TON	HMMWV
3.60	3.33	3.18	3.00	2.57

AN/AVS-6 (HMMWV)

Could not see the road.	1

AN/PVS-14 (HMMWV)

It takes 2-3 seconds to recover from the blooming. Could use my eye to see though.	3

Headlights very high.	1
Could see, but not well. Used my other eye.	2
Couldn't see at all.	1

AN/PVS-7 (HMMWV)

Vehicle lights; couldn't see.	1

11. During this exercise, were you exposed to bright light while driving and wearing the NVGs?

AN/AVS-6 (HMMWV)

8 Yes
1 No
1 NR

Vehicle(s) blinded me.	4
Could not see.	1

AN/AVS-6 (5-TON)

5 Yes
0 No

In the lights of other vehicles.	1

AN/PVS-14 (HMMWV)

30 Yes
0 No

Vehicle lights; bright lights.	7
Had to slow down a bit.	1

AN/PVS-14 (5-TON)

5 Yes
0 No

Headlights of oncoming vehicles.	1

AN/PVS-7 (HMMWV)

10 Yes
0 No

Truck lights.	4

12. If yes, were you able to maintain control of your vehicle?

AN/AVS-6 (HMMWV)

8 Yes
1 No
1 NR

Even though the lights were on, it was easy to maintain control.	1
Had to cover lens and use naked eye to navigate.	1
Takes a few seconds to adjust to the light.	1
Had to slow down a lot.	1

AN/AVS-6 (5-TON)

5 Yes
0 No

AN/PVS-14 (HMMWV)

28 Yes
1 No
1 NR

With light turned down, it was easy.	2
Had to slow down to focus; stop and reorient.	2
Would close one eye; slowed me down.	2
Have to come to a stop to adjust NVGs.	1

AN/PVS-14 (5-TON)

3 Yes
2 No

AN/PVS-7 (HMMWV)

10 Yes
0 No

Slowed down almost to a stop and veered off to the left.	2

13. During this exercise, did the NVG shut down due to high light exposure?

AN/AVS-6 (HMMWV)

0 Yes
9 No
1 NR

AN/AVS-6 (5-TON)

0 Yes
4 No
1 NR

AN/PVS-14 (HMMWV)

0 Yes
30 No

AN/PVS-14 (5-TON)

0 Yes
4 No
1 NR

Seem to fog up, but it wasn't foggy.	1

AN/PVS-7 (HMMWV)

0 Yes
10 No

14. What is your overall rating of the device you used for driving?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE

AN/AVS-6		AN/PVS-14		AN/PVS-7
HMMWV	5-TON	HMMWV	5-TON	HMMWV
5.90	5.65	4.72	4.39	4.43

AN/AVS-6 (HMMWV)

Best so far.	1
Picture could be brighter and adjust better in lighter to darker.	1

AN/PVS-14 (HMMWV)

Still like the AN/AVS-6.	1
Depth perception not good.	1
Fogged and blurred; hard to balance both eyes.	3
Hard to tell where to turn.	1
Would not recommend for long periods because of eye strain.	1
Head mount is bouncy.	2

AN/PVS-14 (5-TON)

Helmet was loose.	1
It was like one eye was dead.	1

AN/PVS-7 (HMMWV)

Can't really see left side.	1

APPENDIX D

DRIVING TIMES BY TYPE DEVICE AND DRIVER

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DRIVING TIMES BY TYPE DEVICE AND DRIVER

Soldier number – iteration number	Device	Time (seconds)
1 – 1	AN/PVS–14	1141
1 – 2	AN/PVS–14	752
1 – 3	AN/AVS-6	768
1 – 4	AN/PVS–14	591
1 – 5	AN/PVS-7	790
2 – 1	AN/AVS-6	802
2 – 2	AN/PVS–14	1205
2 – 3	AN/PVS–14	851
2 – 4	AN/PVS-7	777
2 – 5	AN/PVS–14	822
3 – 1	AN/AVS-6	1455
3 – 2	AN/PVS–14	1754
3 – 3	AN/PVS–14	1319
3 – 4	AN/PVS-7	952
3 – 5	AN/PVS-14	741
4 – 1	AN/PVS-14	900
4 – 2	AN/PVS-14	910
4 – 3	AN/AVS-6	860
4 – 4	AN/PVS-14	997
4 – 5	AN/PVS-7	830
5 – 1	AN/PVS-14	325XXX
5 – 2	AN/PVS-14	1200
5 – 3	AN/AVS-6	1032
5 – 4	AN/PVS-14	995
5 – 5	AN/PVS-7	957
6 – 1	AN/PVS-14	1122
6 – 2	AN/AVS-6	1100
6 – 3	AN/PVS-14	1075
6 – 4	AN/PVS-14	949
6 – 5	AN/PVS-7	939
7 – 1	AN/PVS-14	1170
7 – 2	AN/AVS-6	1170
7 – 3	AN/PVS-14	1281
7 – 4	AN/PVS-14	1054
7 – 5	AN/PVS-7	975
8 – 1	AN/AVS-6	930
8 – 2	AN/PVS-14	1915
8 – 3	AN/PVS-14	958
8 – 4	AN/PVS-7	749
8 – 5	AN/PVS-14	798
9 – 1	AN/PVS–14	1429
9 – 2	AN/PVS–14	1260
9 – 3	AN/AVS–6	905
9 – 4	AN/PVS–14	975
9 – 5	AN/PVS–7	957
10 – 1	AN/PVS–14	694
10 – 2	AN/PVS–14	645
10 – 3	AN/PVS–14	720
10 – 4	AN/AVS-6	595
10 – 5	AN/PVS–7	587

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13. ABSTRACT *(Maximum 200 words)*

The Human Research and Engineering Directorate of the U.S. Army Research Laboratory conducted an assessment to provide the data and analysis of the AN/PVS-14 monocular night vision device (MNVD) and the AN/AVS-6 aviator's night vision imaging system (ANVIS) for the safety certification process. The Communications-Electronics Command Directorate for Safety Risk Management, Fort Monmouth, New Jersey, will use the results of the assessment to determine the suitability of both devices for driving. The four characteristics assessed included (a) the number and nature of training requirements for each system for night driving; (b) the time to complete and the number of errors made while drivers negotiated a hardtop driving course; (c) the time to complete and the number of errors made while drivers negotiated a cross-country driving course; (d) the number and nature of problems related to soldier performance, as well as the number and severity of safety hazards noted.

The 15 soldiers who participated in the assessment drove with the AN/PVS-14, the AN/AVS-6, and the baseline system (AN/PVS-7D) in a predetermined sequence to equalize the environmental and learning effects between systems. Two different terrain driving courses were used: hardtop and cross country. The 15 soldiers were divided into two subgroups: 5-ton truck drivers and high mobility multipurpose wheeled vehicle drivers.

Findings indicated that the soldiers were able to drive with the AN/PVS-14 MNVD and the AN/AVS-6 ANVIS as well as, if not better than, they could with the baseline system (AN/PVS-7D). No problems surfaced that should preclude safety certification of driving with the night vision devices on terrain similar to that used in the study.

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